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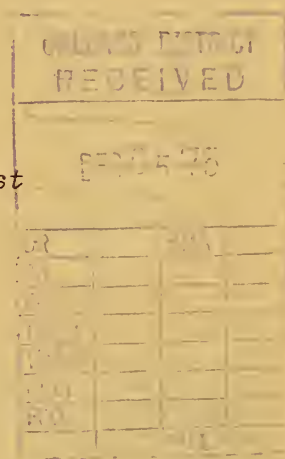
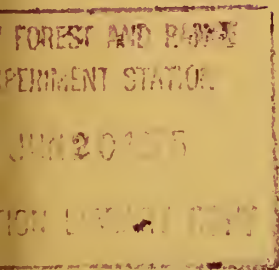
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SOIL MOISTURE DEPLETION AND GROWTH RATES AFTER THINNING PONDEROSA PINE

by

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ABSTRACT

In 1967, a study was started near Baker, Oregon, to compare soil moisture depletion and growth rates on unthinned plots with other plots thinned to spacings of 12, 15, 18, and 21 feet (3.7, 4.5, 5.5, and 6.4 m). The first summer after thinning, soil moisture depletion was 9.3, 9.0, and 6.1 inches (23.6, 22.9, and 15.5 cm) in the control, lightly thinned, and heavily thinned plots, respectively. Depletion from heavily thinned plots averaged 3.3 inches (8.4 cm) less than from control plots during the first three summers after treatment. Light thinning had no measurable effect on moisture depletion. Growth was greatest on the stand thinned to 15-foot (4.6-m) spacing.

KEYWORDS: Soil moisture, thinnings, ponderosa pine, *Pinus ponderosa*.

In 1967 a study was begun on moisture input and soil moisture depletion after ponderosa pine (*Pinus ponderosa* Laws.) was thinned. The purpose of this paper is to present the soil moisture and related results along with some tree growth data.

THE STUDY AREA

The study area is on the Wallowa-Whitman National Forest about 15 miles (24 km) southwest of Baker, Oregon (fig. 1). Elevations of the

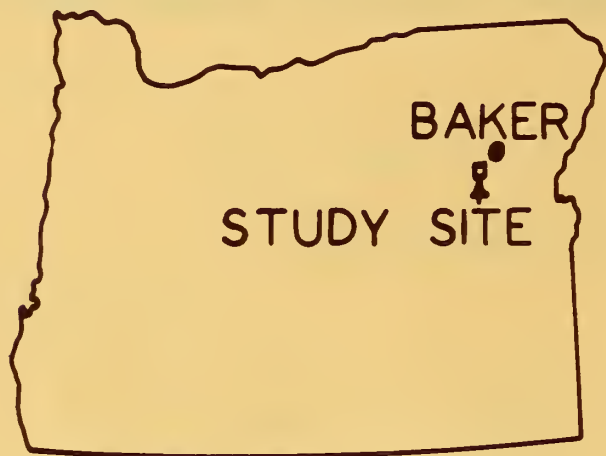


Figure 1.--The study area is located about 15 miles (24 km) southwest of Baker, Oregon.

plots range from 4,500 to 4,800 feet (1372 to 1463 m). The aspect is generally southwest on slopes of inclination less than 20 percent. The vegetation is predominantly ponderosa pine which was established after heavy logging around 1900. Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and western larch (*Larix occidentalis* Nutt.) are minor components of the overstory. Because of the dense canopy, understory vegetation was scarce before thinning. After thinning, native grasses such as elk sedge (*Carex geyeri* Bott.) and pinegrass (*Calamagrostis rubescens* Buckl.) became prominent.

Stand age at the time of thinning was about 50 years, height of dominants averaged 40 feet (12.2 m), and growth rates averaged only about 0.05 inch (1.27 mm) per year. Sartwell and Dolph^{1/} estimated site index at 65 and site class as V.

METHODS

The study design for evaluating thinning effects consisted of 10 plots, each containing about 25 acres (10.1 ha). Each of the following intensities was assigned to two plots: (1) no thinning, (2) remove all suppressed trees, (3) remove all suppressed and intermediate trees, (4) remove all suppressed, intermediate, and poorly placed codominant trees, and (5) remove all except the dominant and codominant trees.

^{1/} Charles Sartwell and Robert E. Dolph, Jr. Silvicultural and direct control of mountain pine beetle in second-growth ponderosa pine. Paper being prepared.

Average spacing between residual trees was 12, 15, 18, and 21 feet (3.7, 4.6, 5.5, and 6.4 m) for treatments 2, 3, 4, and 5, respectively. Soil moisture and snow measurements were made on pairs of plots receiving treatments 1, 2, and 5.

On each plot receiving treatments 1, 2, or 5, 25 equally spaced sample points were chosen for snow sampling. Then five of these points were randomly selected for soil moisture measurements. Soil moisture access tubes were installed as deeply as possible during the summer of 1967--right after the thinnings were completed. Of the 30 access tubes installed (6 plots with 5 tubes each), 8 were installed to 6 feet (1.8 m), 14 to 5 feet (1.5 m), 7 to 4 feet (1.2 m), and 1 to 3 feet (0.9 m).

Snow depth and density data were collected starting about February 1 when peak accumulation usually occurred and at approximately 2-week intervals until complete snowmelt. Soil moisture measurements were made with neutron-scattering instruments at 1-foot (30-cm) intervals in the profile, beginning at the 6-inch (15-cm) level. The first reading each season was made as soon as possible after snowmelt and at approximately monthly intervals through the summer. The final reading each year was in the latter part of September when annual soil moisture levels are lowest. Precipitation was measured with one storage gage between November 1968 and October 1971.

Soil moisture depletion was analyzed using the methods of Barrett (1970) and Sartz (1972). In this analysis, the difference in moisture content held by the profile between the first and last observation each summer was taken as the response variable. This value is not the same as total moisture use because some precipitation falls during the summer months and part of the moisture held in the spring is lost by drainage. A major weakness of the method is that an indicated depletion difference between thinning intensity is logically underestimated because drainage will be greater from the profile which retains the most water. Therefore, moisture depletion results presented here should be considered as qualitatively correct, but perhaps not exact quantitatively. A more rigorous statistical analysis was not possible because of the spatial variability of total moisture content and the lack of sufficient sites to adequately define mean values. Moisture changes between dates, as used here, are less variable between sites than total moisture contents; thus fewer sampling points are needed for a given degree of accuracy (Hewlett et al. 1963).

Basal area was measured on all plots just after thinning in 1967 and again in 1972. Growth rate was measured on cores taken from five dominant or codominant trees in each of the unthinned, lightly thinned, and heavily thinned plots at the end of the 1973 growing season.

RESULTS AND DISCUSSION

Although precipitation measurements are for a short time period, they correlate well with records from a station near Baker ($R^2 = 0.88$) where measurements began more than 80 years ago. Precipitation at the Baker station was slightly below the long-term average in 1969, 40 percent above average in 1970, and 23 percent above average in 1971. Assuming that the same relationships hold for the study area, average annual precipitation there is about 18 inches (46 cm). The summer months of July through September are driest with 12 percent of the annual total, while November through January are wettest with more than 30 percent.

Snow pack data presented in table 1 were collected between February 3 and 6 of each year--the approximate time of maximum annual snow accumulation. Although the snow pack was not very deep during the study, there

Table 1.--Average snow depth and water content (w.c.) at peak snow pack

Treatment	1968		1969		1970		1971	
	Depth	w.c.	Depth	w.c.	Depth	w.c.	Depth	w.c.
- - - - - Inches (centimeters) - - - - -								
Control	10.0 (25.4)	2.45 (6.22)	20.5 (52.1)	3.40 (8.64)	12.0 (30.5)	3.50 (8.89)	8.6 (21.8)	2.70 (6.86)
Lightly thinned	13.0 (33.0)	3.25 (8.26)	24.0 (61.0)	4.80 (12.19)	15.5 (39.4)	4.30 (10.92)	11.9 (30.23)	3.50 (8.89)
Heavily thinned	14.0 (35.6)	3.65 (9.27)	27.0 (68.6)	5.20 (13.21)	19.1 (48.5)	5.10 (12.95)	15.2 (38.6)	4.40 (11.18)

is a direct relationship between snow depth and thinning intensity as well as between water content and thinning intensity. Snow disappeared from all plots at about the same time each year. Several studies of snow accumulation after timber harvest in the Western States have been reported, and the results generally agree with results in table 1; i.e., snow accumulation was deepest in the heavily thinned stand and least in the unthinned control. However, there is disagreement as to whether the observed results are caused by redistribution of snow by wind or whether snow interception from the natural forest is significantly greater than from the thinned or harvested plots (Hoover 1971). Since wind measurements are not available for the present study, it is not possible to determine a cause and effect relationship.

The soil profile averaged about 5 feet (1.5 m) deep. The soils are fine textured and have a high moisture retention, even at 15-bar suction (table 2).

Moisture lost from the profile between spring and autumn varied

Table 2.--Physical characteristics of soil

Depth interval (cm)	Sand	Silt	Clay	Bulk density	pH	Moisture retention at (bars)				
						0.2	0.5	1.0	5.0	15.0
<div>- - - Percent - - - g/cm³ - - - - Percent by volume - - - -</div>										
7-30	34	51	15	1.26	4.60	35.0	27.5	23.0	13.5	12.5
30-60	35	20	45	1.69	4.35	46.5	36.5	34.0	23.5	20.5
60-150	50	18	32	1.87	4.50	43.5	38.0	34.0	24.0	22.5

considerably between sites. For example, in the heavily thinned plots, moisture loss for 1968 varied from 2.5 to 10.6 inches (6.4 to 26.9 cm), averaging 6.1 inches (15.5 cm). In the control plots, loss values varied from 5.6 to 14.4 inches (14.2 to 36.6 cm), averaging 9.2 inches (23.4 cm). There was no significant correlation between moisture loss at a measurement site and the distance from the site to the nearest tree. The lower loss from the heavily thinned plots is attributed to reduced evapotranspiration losses. Moisture losses from the control plots exceeded losses from the heavily thinned plots by 3.1, 4.5, and 2.4 inches (7.9, 11.4, and 6.1 cm) during the first, second, and third year after treatments, respectively (fig. 2). These values were significantly

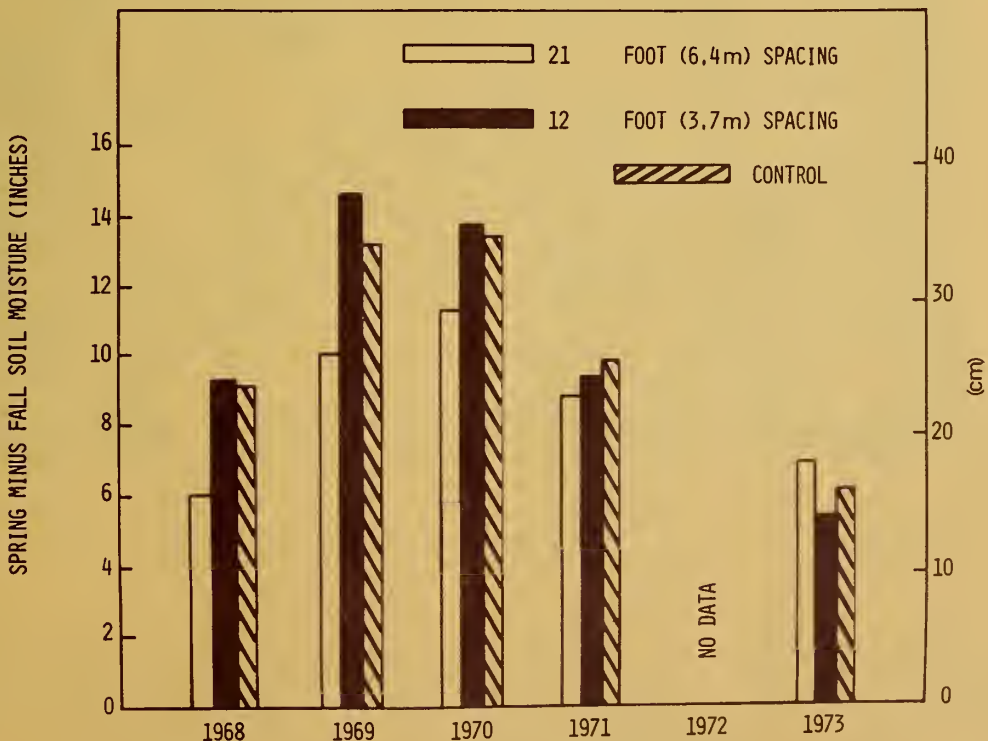


Figure 2.--Difference in soil moisture held by the profile in spring and fall as a function of thinning intensity and years after thinning.

greater than zero at the 0.05 level in a one-way analysis of variance test. Although moisture depletion from the lightly thinned plots was slightly less than from the control, the difference is not significantly different from zero at even the 0.10 level.

It is somewhat surprising that results presented in figure 2 indicate no significant difference in moisture depletion from either treatment during the fourth and sixth years after thinning. One plausible explanation is that after 3 years, the remaining trees were able to extend their roots and crowns into spaces formerly occupied by the cut trees. Consequently, water use by these trees was much greater than before. Tree crowns are definitely wider and thicker in the heavily thinned plots, but no attempt was made to test the idea that tree roots invaded the unoccupied spaces. Reproduction and other low vegetation would be expected to decrease water supplies in the thinned areas. Although reproduction is scarce, figure 3 shows native grasses are quite thick along the soil moisture transect, and they probably significantly influenced the moisture regime.



Figure 3.--This photograph of a plot thinned to 21-foot (6.4-m) spacing was made 6 years after treatments. Note the dense grass cover along the soil moisture sampling transects.

Changes in basal area between late summer 1967 and 1972 are shown in table 3. It appears that optimum spacing for tree growth is 15 feet (4.6 m), at least for the first 5 years. The wider spacing may be more desirable over a longer period, however.

Table 3.--Basal area changes during the 5 years
after thinning^{1/}

Average spacing treatment	Basal area		
	1967	1972	Change
- - - Square feet per acre (m ² /ha) - - -			
Unthinned	173.2 (40.2)	152.5 (35.4)	-20.7 (-4.8)
12 ft (3.66 m)	116.8 (27.1)	113.5 (26.3)	-3.3 (-0.8)
15 ft (4.57 m)	85.8 (19.9)	89.0 (20.6)	+3.2 (+0.7)
18 ft (5.49 m)	61.8 (14.3)	64.8 (15.0)	+3.0 (+0.7)
21 ft (6.40 m)	35.0 (8.1)	37.2 (8.6)	+2.2 (+0.5)

^{1/} These data, collected in late summer of both years, were provided by Charles Sartwell, Entomologist, at Forestry Sciences Laboratory, Corvallis, Oregon.

Growth was also measured on 10 cores from dominant trees in treatments 1, 2, and 5. Growth rate within the heavily thinned plot accelerated sharply from age 50 to 55 years (after treatment) and trees in the lightly thinned and control plots followed trends similar to each other (fig. 4). In the control, lightly thinned, and heavily thinned stands, 5-year diameter increment was 0.25, 0.35, and 1.1 inch (6.4, 8.9, and 27.9 mm), respectively. The obvious conclusion is that these stagnant stands must be thinned to a spacing greater than 12 feet (3.7 m) in order to stimulate radial growth rate.

Sartwell and Dolph (see footnote 1) concluded that the light thinning had little influence on mountain pine beetle (*Dendroctonus ponderosa*) activity, but they reasoned that light thinning may be beneficial to younger stands.

These soil moisture and diameter growth results are similar to those reported by Barrett (1970) for his thinning study in ponderosa pine near Bend, Oregon. Although Barrett's main objective was growth rate response, he also measured soil moisture with sampling points located in the center of the geometric figure formed by four trees. Since the sampling points in the present study were randomly located, the studies are not strictly comparable. However, it is worth noting that Barrett's results still showed decreased moisture use in thinned stands after 8 years, but in the present study no treatment effect could be detected 3 years after the heavy thinning. The dense ground cover along the soil moisture transects (fig. 3) could be a factor in this different response.

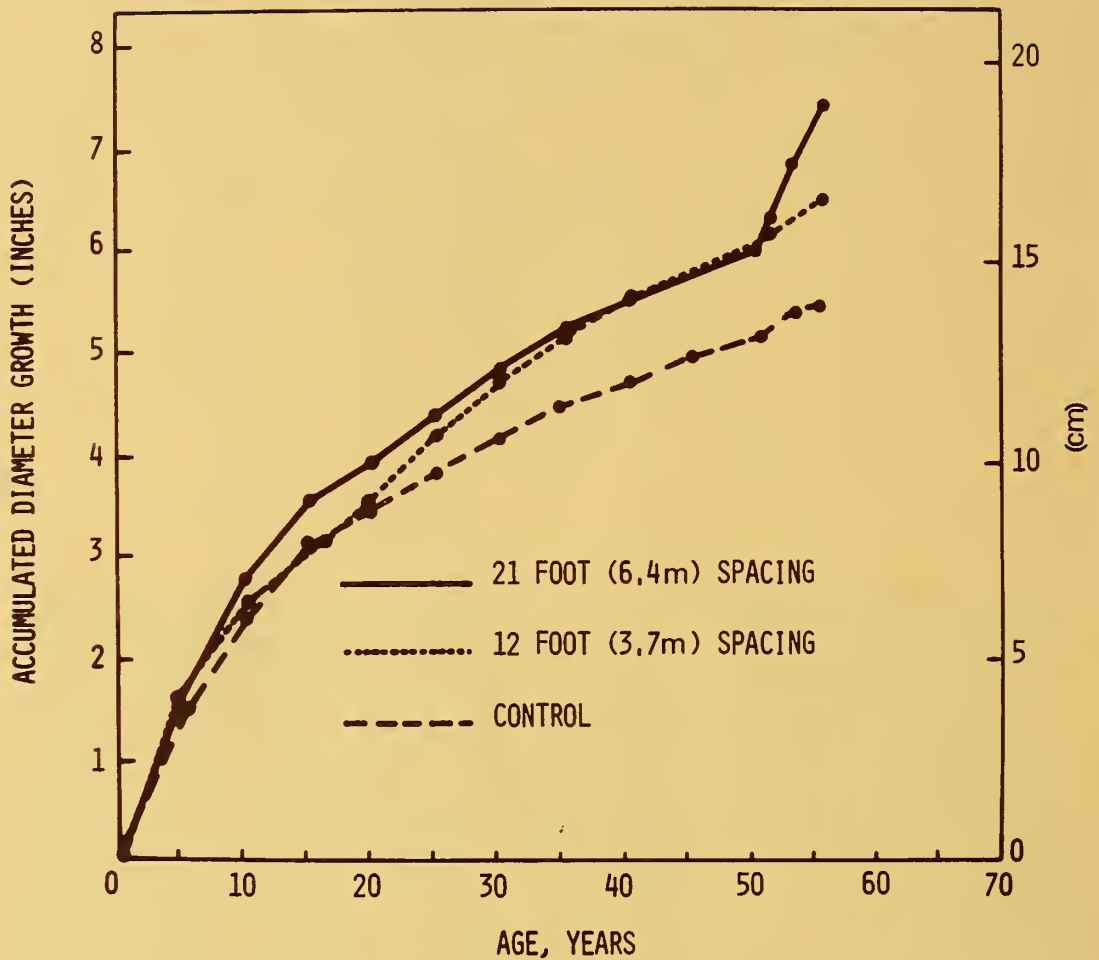


Figure 4.--Accumulated diameter growth of stands receiving light thinning, heavy thinning, and no thinning.

CONCLUSION

This study, while not providing definitive answers to the questions of thinning effects on moisture depletion and growth response, provides clues to these effects. Heavy thinning produced temporary reductions in moisture depletion during summer months and accelerated growth rates on the residual stems. Approximately 25,000 acres (10 125 ha) of stagnant ponderosa pine forest east of the Cascade Range in Washington and Oregon are being thinned each year.^{2/} If the results of this study are representative, approximately 20,000 acre-feet ($2.47 \times 10^7 \text{ m}^3$) less water are used

^{2/} Personal communication with Reforestation and Stand Improvement Specialists, U.S. Forest Service, Region 6, Portland, Oregon.

by trees in thinned areas each year. It was not possible to determine the fate of the extra moisture held by the soil profile after treatment, but the thinned stands are too scattered to significantly affect surface water supplies. The higher moisture levels in the soil, along with additional sunlight, will stimulate growth of grasses and forbs as well as residual trees. According to Sartwell and Dolph (see footnote 1), tree mortality by mountain pine beetle was reduced 10-fold by thinning.

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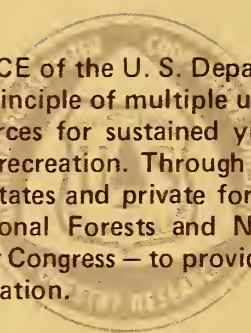
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